

UNITED STATES PATENT APPLICATION

FOR

**OVERMOLDED MCM WITH INCREASED
SURFACE MOUNT COMPONENT RELIABILITY**

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EV346915238US

"EXPRESS MAIL" mailing label number

Date of Deposit 7/17/03

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03SKY0042

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention is generally in the field of semiconductor device packaging.

More specifically, the invention is in the field of overmolded module packaging.

5 2. RELATED ART

Electronic devices, such as cell phones, typically utilize an MCM (multi-chip module or multi-component module) to provide a high level of circuit integration in a single molded package. The MCM can include, for example, one or more dies and a number of surface mount components ("SMCs"), which are mounted on a single circuit board. The circuit board including the SMCs can be encapsulated in a molding process to form an overmolded MCM package.

By way of background, in a conventional MCM fabrication process, solder mask is patterned and developed on a circuit board to form solder mask openings, which expose solderable areas on the circuit board, such as metal pads. A SMC can be mounted on printed circuit board by soldering the terminals of the SMC to exposed metal pads, which are situated in solder mask openings. When the SMC is mounted on the circuit board, a gap is formed between the bottom of the SMC and the solder mask, which is situated on the top surface of the circuit board.

During the molding process, a molding compound, such as an epoxy molding compound, is formed over each SMC and also fills the gap formed between the bottom of the SMC and the solder mask situated on the top surface of the circuit board. However, since the gap is relatively narrow, the molding compound may not completely fill the gap

underneath the SMC. As a result, one or more voids can form in the molding compound situated underneath the SMC. After completion of the molding process, preconditioning tests are typically performed on the overmolded MCM to ensure that the overmolded MCM package meets Interconnect Packaging Committee ("IPC")/Joint Electronic Device Engineering Council ("JEDEC") moisture sensitivity specifications and to simulate customer handling. The preconditioning tests include a moisture soak and reflow test, which can cause the solder that secures the terminals of the SMC to the circuit board to melt. As a result, solder can flow into any voids that were formed in the molding compound underneath the SMC during the molding process and cause the terminals of the SMC to short and, thereby, cause the SMC to fail. Thus, voids formed underneath a SMC reduce the reliability of the SMC and, consequently, reduce the reliability of the overmolded MCM that includes the SMC.

Thus, there is a need in the art for more a more reliable SMC in an overmolded MCM.

SUMMARY OF THE INVENTION

The present invention is directed to overmolded MCMs with increased surface mount component reliability. The present invention addresses and resolves the need in the art for a more reliable SMC in an overmolded MCM.

5 According to one exemplary embodiment, an overmolded module comprises a surface mount component situated over a substrate, where the surface mount component comprises a first terminal and a second terminal. For example, the overmolded module can be an MCM and the substrate can be a laminate circuit board. The surface mount component may be a resistor, a capacitor, or an inductor, for example. The overmolded
10 module further comprises a first and a second pad situated on the substrate, where the first pad is connected to the first terminal and the second pad is connected to the second terminal.

 According to this exemplary embodiment, the overmolded module further comprises a solder mask trench situated underneath the surface mount component, where
15 the solder mask trench is filled with molding compound. The overmolded module further comprises a moldable gap situated between a bottom surface of the surface mount component and a top surface of the substrate, where the moldable gap includes the solder mask trench; the moldable gap can be filled with the molding compound. The overmolded module further comprises an encapsulation or molding process to form an
20 overmolded package, where the overmold is situated over and under the surface mount component. Other features and advantages of the present invention will become more readily apparent to those of ordinary skill in the art after reviewing the following detailed

description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a cross sectional view of an exemplary structure including an exemplary surface mount component in accordance with one embodiment of the present invention.

- 5 Figure 2 illustrates an exemplary surface mount component layout in accordance with one embodiment of the present invention.

Figure 3 illustrates a cross sectional view of an exemplary structure including an exemplary surface mount component in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to overmolded MCMs with increased surface mount component reliability. The following description contains specific information pertaining to the implementation of the present invention. One skilled in the art will
5 recognize that the present invention may be implemented in a manner different from that specifically discussed in the present application. Moreover, some of the specific details of the invention are not discussed in order not to obscure the invention.

The drawings in the present application and their accompanying detailed description are directed to merely exemplary embodiments of the invention. To maintain
10 brevity, other embodiments of the present invention are not specifically described in the present application and are not specifically illustrated by the present drawings. It is noted that although an exemplary SMC is utilized to illustrate the present invention, the present invention also applies to two or more SMCs and/or other surface mount components that have more than two terminals (also referred to as a "surface mount device" in the present
15 application), as well as variations of the invention necessary for assembling multiple SMCs in an overmolded or encapsulated MCM.

Figure 1 shows a cross-sectional view of structure 100, which is utilized to describe one embodiment of the present invention. Certain details and features have been left out of Figure 1 that are apparent to a person of ordinary skill in the art. Structure 100
20 includes SMC 102, which is situated on substrate 104, and can be, for example, an MCM, i.e. a multi-chip module or a multi-component module. It is noted that although only one SMC is shown in Figure 1 to preserve brevity, structure 100 can comprise any number of

SMCs.

As shown in Figure 1, pads 106 and 108 are situated on top surface 110 of substrate 104, which can be, for example, a laminate circuit board. Pads 106 and 108 can comprise a metal, such as copper, and can be patterned on top surface 110 of substrate 104 in a manner known in the art. Also shown in Figure 1, solder mask 112 is situated on top surface 110 of substrate 104 and may or may not be over portions of pads 108 and 106 and can comprise an appropriate masking material as known in the art. Solder mask 112 can have thickness 114, which can be, for example, between approximately 30.0 and 55.0 micrometers.

Further shown in Figure 1, terminal 116 of SMC 102 is attached to pad 106 by solder joint 120 and terminal 118 of SMC 102 is attached to pad 108 by solder joint 122. SMC 102 can be, for example, a passive component like a resistor, a capacitor, or an inductor and/or can be a discrete or active component like a diplexer, diode, or SAW (Surface Acoustic Wave) filter and can comprise a ceramic material, plastic material, or other appropriate material as known in the art. Terminals 116 and 120 of SMC 102 can comprise metal, which can be plated on respective ends of SMC 102 in a manner known in the art. In one embodiment, terminals 116 and 120 can be situated underneath SMC 102, for example, in a land grid array pattern. Solder joints 120 and 122 are utilized to form a mechanical and electrical connection between terminals 116 and 118 of SMC 102 and pads 106 and 108, respectively.

Also shown in Figure 1, solder mask trench 124 is situated between bottom surface 126 of SMC 102 and top surface 110 of substrate 104 and between pads 106 and 108 of

SMC 102. Solder mask trench 124 can be formed by appropriately patterning and developing an opening in solder mask 112. In the present embodiment, solder mask trench 124 is formed over a non-solderable area on substrate 104. In contrast, a conventional solder mask opening is formed only over a solderable area or to expose an interconnect area on substrate 104. Further shown in Figure 1, moldable gap 125 is situated between bottom surface 126 of SMC 102 and top surface 110 of substrate 104 and includes solder mask trench 124. Moldable gap 125 can be filled with molding compound in a molding process and has height 128, which can be, for example, between approximately 45.0 and 65.0 micrometers.

Thus, by forming solder mask trench 124 underneath SMC 102, the present invention achieves a moldable gap, i.e. moldable gap 125, that is significantly larger than a conventional moldable gap. For example, in a conventional process, solder mask 112 would extend between pads 106 and 108 underneath SMC 102. As a result, a conventional moldable gap that would be formed between solder mask 112 and bottom surface 126 of SMC 102 would have a height equal to height 130, which can be, for example, between approximately 10.0 and 25.0 micrometers. Thus, by forming solder mask trench 124, the present invention advantageously achieves a significantly larger moldable gap that improves molding compound flow underneath SMC 102 and, consequently, minimizes void formation underneath SMC 102. As a result, the present invention advantageously minimizes the risk of shorting between terminals 120 and 122, during, for example, reflow assembly, which increases the reliability of SMC 102.

In one embodiment, a structure, such as an MCM, can comprise a surface mount

device situated over a substrate, such as substrate 104, where the surface mount device comprises more than two terminals, and where each of the more than two terminals is connected to a respective pad situated on the top surface of the substrate. In that embodiment, a solder mask trench can be situated underneath the surface mount device and can provide similar advantages as discussed above in relation to the embodiment of the present invention in Figure 1. The surface mount device can be a leadless surface mount device and can comprise, for example, a diplexer, a low pass filter, a bandpass filter, SAW filter or a discrete or active packaged device like a diode. In one embodiment, the surface mount device discussed above can be a packaged leaded device.

Figure 2 shows an exemplary layout of structure 100 in Figure 1 in accordance with one embodiment of the present invention. In particular, SMC 202, pads 206 and 208, and solder mask trench 224 in layout 200 in Figure 2 correspond, respectively, to SMC 102, pads 106 and 108, and solder mask trench 124 in structure 100 in Figure 1. It is noted that in Figure 2 solder mask, such as solder mask 112 in Figure 1, surrounds but is not situated in solder mask trench 224 and solder mask openings 250 and 252. As shown in Figure 2, solder mask openings 250 and 252 are situated over pads 206 and 208, respectively, and can be formed by patterning and developing appropriate openings in solder mask, such as solder mask 112 in Figure 1. Solder mask openings 250 and 252 expose portions of respective pads 206 and 208 such that the exposed portions of pads 206 and 208 can be soldered to respective terminals of SMC 202.

Also shown in Figure 2, solder mask area 254 is situated between pad 206 and solder mask trench 224 and solder mask area 256 is situated between pad 208 and solder

mask trench 224. In one embodiment, solder mask trench 224 is extended to the edges of pads 206 and 208 such that solder mask area 254 and 256 are eliminated. In one embodiment, solder mask trench 224 surrounds pads 206 and 208 and includes the area between pads 206 and 208 such that pads 206 and 208 are completely exposed in solder mask trench 224. Further shown in Figure 2, SMC 202 is situated over solder mask openings 250 and 252 and over solder mask trench 224.

Figure 3 shows a cross-sectional view of structure 100 in Figure 1 after molding compound has been applied in accordance with one embodiment of the present invention.

In Figure 3, substrate 304, pads 306 and 308, top surface 310, solder mask 312, terminals 316 and 318, solder joints 320 and 322, solder mask trench 324, moldable gap 325, and bottom surface 326 in structure 300 correspond, respectively, to substrate 104, pads 106 and 108, top surface 110, solder mask 112, terminals 116 and 118, solder joints 120 and 122, solder mask trench 124, moldable gap 125, and bottom surface 126 in structure 100 in Figure 1.

As shown in Figure 3, overmold 360 is situated over solder mask 312 and over SMC 302. Overmold 360 can comprise an epoxy molding compounding or other appropriate molding compound and can be formed in a molding process in a manner known in the art. Also shown in Figure 3, undermold 362 is situated in moldable gap 325, which includes solder mask trench 324. Undermold 362 can comprise a similar molding compound as overmold 360 discussed above and can be formed by filling moldable gap 325 with molding compound in a molding process in a manner known in the art. Overmold 360 and undermold 362 may or may not be achieved during the same

molding / encapsulation process in a manner known in the art.

By forming solder mask trench 324, the present invention advantageously achieves a moldable gap underneath SMC 302 that is more easily filled with molding compound, which reduces the risk of forming voids in the moldable gap during the molding process.

5 As a result, the present invention advantageously achieves a SMC having increased reliability. Additionally, by utilizing solder mask trench 324 to increase the size of the moldable gap, i.e. moldable gap 325, the present invention advantageously achieves a more consistent mold-fill, i.e. undermold 362, between solder joints 320 and 322.

It is appreciated by the above detailed description that the invention provides a
10 SMC having increased reliability, where the SMC is situated in a structure, such as an overmolded MCM. From the above description of the invention it is manifest that various techniques can be used for implementing the concepts of the present invention without departing from its scope. Moreover, while the invention has been described with specific reference to certain embodiments, a person of ordinary skill in the art would
15 appreciate that changes can be made in form and detail without departing from the spirit and the scope of the invention. Thus, the described embodiments are to be considered in all respects as illustrative and not restrictive. It should also be understood that the invention is not limited to the particular embodiments described herein but is capable of many rearrangements, modifications, and substitutions without departing from the scope
20 of the invention.

Thus, overmolded MCM with increased surface mount component reliability has been described.